6.Resistance to Starvation of Pale and Black Larvae of the Armyworm, Leucania separata Walker (Lepidoptera: Noctuidae)

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Resistance to Starvation of Pale and Black Larvae of the Armyworm, *Leucania separata* Walker (Lepidoptera : Noctuidae)[1] Syun'iti Iwao (Entomological Laboratory, College of Agriculture, Kyoto University, Kyoto). Received April 28, 1967. *Botyu-Kagaku*, 32, 44, 1967.

6. アワヨトウの淡色型および黒色型幼虫の飢餓に対する抵抗性 巌 俊一 (京都大学農学部昆虫学研究室) 42. 4. 28 受理

アワヨトウ幼虫は1頭飼育すると淡色型，高密度飼育では黒色型になる．両者の絶食下での生存日数を，21°C 関係湿度 5, 58 および 97% の条件下で調べた所，どの湿度でも黒色型の生存日数が有意に長く，とくに高湿度の場合にその差が大きくなるようであった．この結果を，本種の相変異についての他の知見やワタリバッタの場合と比較して論じた．

As reported previously (Iwao, 1962), in the armyworm *Leucania separata* Walker, the active black larvae appearing at high population density seem to be more resistant to starvation than the sluggish pale larvae that appear when individuals are reared isolated. To confirm this, the survival of both types of the final (6th) instar larvae under starvation was observed at low, medium, and high relative humidities.

Just after the 5th moult, the larvae which had been reared in isolation (pale larvae) and in crowds (black larvae) were confined singly in glass tubes that were covered with perforated lids at both ends, and assigned to three desiccators in which relative humidities were adjusted to about 5, 58, and 97 per cent, respectively. Temperature was maintained at 21°C during the experiment.

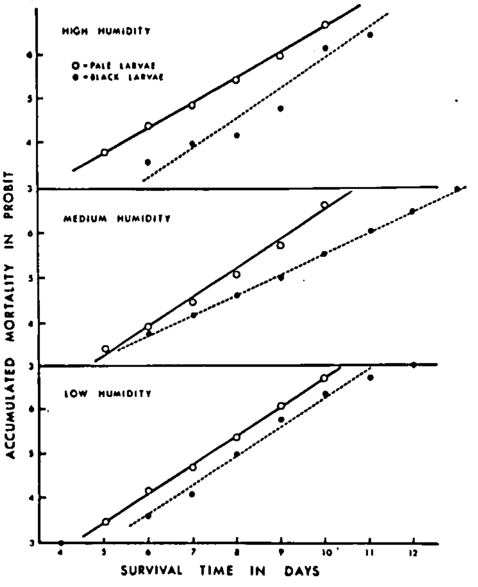

Fig. 1. Time-mortality curves of the pale and black larvae of *Leucania separata* when they were starved at various levels of humidity.

Each larva was weighed before and at intervals during starvation. The tubes were inspected daily for mortality, and when dead larvae were found they also were weighed immediately.

The time-mortality relationships of the starved larvae at different humidities are shown in Fig. 1, in which the accumulated mortality in probits is plotted against the number of days to death (see Bliss, 1937). At any humidity tested, the black larvae had a tendency to live longer when starved than the pale larvae. Also, the distribution of deaths in pale larvae were approximately normal at each humidity, whereas that in black larvae seemed to be more variable.

In the pale western cutworm, *Agrotis orthogonia* Morr., Jacobson and Blakeley (1957) have shown that excessive moisture was as harmful as severe desiccation when the larvae were being starved. This was also true for the pale larvae of *L. separata*. But, the black larvae seemed to be little affected by excessive moisture, indicating that they might be able to tolerate a wider range of humidity.

The body weight of larvae just after the 5th moult was heavier in black larvae than in pale ones: average weights were 221.9±5.4mg and 202.9±4.3mg, respectively. No significant correlation, however, was detected between the initial weight and the survival time within either group of larvae. According to the author's previous

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Table 1. Survival times and percentage weight losses in the pale and black larvae of *Leucania separata* under starvation.

Relative humidity %	Type of larvae	No. larvae tested	Survival time in days Mean	S.D.**	% Weight loss After 3 days	At death	Av. daily rate of % wt. loss
97	Pale	21	7.19±0.26*	1.66	10.6±1.9*	48.6±2.6*	7.2±0.9*
	Black	19	9.00±0.24	1.53	10.1±2.8	43.8±4.9	5.2±0.8
58	Pale	19	7.79±0.22	1.47	12.8±2.1	60.6±2.7	8.1±0.9
	Black	20	8.85±0.45	2.14	17.4±2.5	60.9±2.5	7.3±0.9
5	Pale	24	7.33±0.17	1.44	22.4±2.8	69.1±3.0	9.9±0.9
	Black	24	8.00±0.21	1.59	25.6±2.7	69.3±2.4	8.7±0.7

* Mean±95% fiducial limits.
** The reciprocal of S.D. corresponds the slope of the probit regression line shown in Fig. 1.

experience, the body weight of pale larvae becomes decidedly heavier than that of black larvae during the feeding period of the 6th instar, but there is no consistent difference in their weight at the beginning of this stage; black larvae are sometimes heavier and sometimes lighter than pale larvae. In another experiment (see Iwao, 1962) black larvae were smaller in size than pale ones, but the former tended to live longer than the latter as in the present experiment. Therefore, the observed difference in survival times between both types of larvae seems not to be attributable to the initial difference in their body weight.

The body weight of larvae gradually decreased during starvation. In Table 1, the weight losses after the first three days of starvation and immediately after death are shown as percentages of the initial weights. During the first three days, the black larvae lost higher percentages of weight than the pale ones at medium and low humidities but about the same at high humidity. This indicates that at lower humidities black larvae might have lost more water during the initial stage of starvation, probably because they have higher metabolic rates than pale larvae (Waku and Iwao, 1960; Okauchi, unpublished). On the other hand, there was no difference between the two types of larvae in their percentage weight losses at death, and so the average daily rate of percentage weight loss throughout the period was higher in pale larvae.

Although the effect of desiccation was indicated by the higher rate of weight losses at low humidity, the difference between pale and black larvae did not widen at low humidity, indicating that both types of larvae may differ chiefly in their ability to withstand starvation rather than desiccation. Since the survival time of insects under starvation is known to be directly correlated with the amount of fat stored up before starvation began (see Fast's review 1964), the fact that black larvae have higher fat contents than pale larvae (Okauchi, *l. c.*) probably is related to their longer survival times.

Albrecht (1962) has shown that in three species of locusts the heavier hatchlings produced by phase *gregaria* parents survive longer when starved than the small ones of *solitaria* origin. In the armyworm, such a maternal influence on the survival capacity has not been tested, and the resistance to starvation of the final instar larvae appears to be not necessarily related to their body weight. In both cases, however, the change in the resistance to starvation occurs in the same direction in relation to phase change. The black larvae of *L. separata* are not only more resistant to starvation but also more tolerant of less suitable food plants (Iwao, *l. c.*). It seems likely, therefore, that in insects exhibiting phase variation, the individuals that appear under crowded conditions have greater resistance to several environmental stresses than those that develop in less dense populations.

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References

Albrecht, F. O.: *Trans. R. Ent. Soc. London*, 114, 335~375 (1962).

Bliss, C. I.: *Ann. Appl. Biol.*, 24, 815~852 (1937).

Fast, P. G.: *Mem. Ent. Soc. Canada*, 37, 1~50 (1964).

Iwao, S.: *Mem. Coll. Agric., Kyoto Univ.*, 84, 1~80 (1962).

Jacobson, L. A. and P. E. Blakeley: *Can. Ent.*, 89, 465~469 (1957).

Waku, Y. and S. Iwao: *Japanese J. Appl. Ent. Zool.*, 4, 70~71 (1960).

綜　説

Metabolism of ^{14}C-labelled Insecticides in Microorganisms, Insects and Mammals.

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Following survey is summarized experiments since 1958 on the conversion of some drin-insecticides in living organisms under comparable conditions. To this aim, we had first to synthesize these insecticides with high specific activity, starting from barium-carbonate-^{14}C. For our metabolism studies we have now synthesized ^{14}C-labelled aldrin, dieldrin[1], endrin[5], telodrin[3], heptachlor[4], dihydroheptachlor[2] and chlordane[4]. A survey of these compounds is given in Fig. 1.

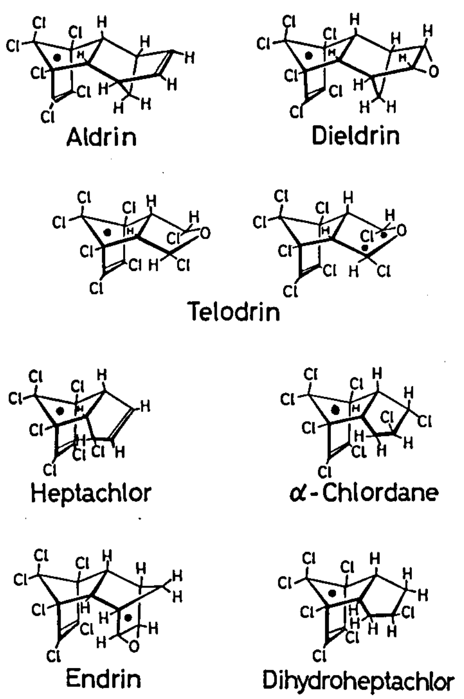

Fig. 1.

The circles in the structural formulae indicate the position of the ^{14}C-labelled atoms. Telodrin was synthesized with the label in 1, 3-position, all others are labelled statistically in the hexachlorocyclopentene ring-system with the exception of endrin, where the ^{14}C-atom is placed in the cyclopentene-ring. Besides well-known insecticides

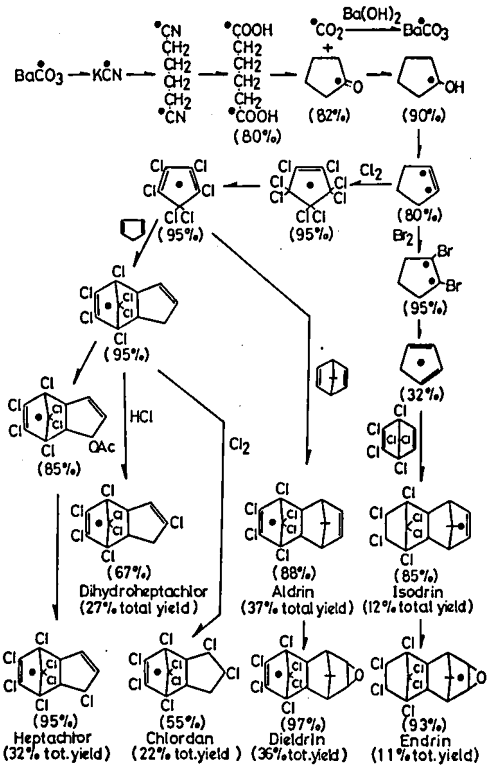

Fig. 2. Synthesis of aldrin-^{14}C, dieldrin-^{14}C, chlordane-^{14}C, heptachlor-^{14}C, dihydroheptachlor-^{14}C and endrin-^{14}C.